THE SAPROXYLIC DATABASE: AN EMERGING OVERVIEW OF THE BIOLOGICAL DIVERSITY IN DEAD WOOD

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RÉSUMÉ. — *La base de données saproxyliques : l'émergence d'un aperçu de la diversité biologique du bois mort*. — Les pays nordiques (Norvège, Suède, Finlande et Danemark) développent une base de données commune, en anglais, avec des informations spécifiques sur l'écologie des espèces saproxyliques. La base de données contient maintenant des informations sur environ 6000 espèces et ce nombre devrait avoisiner 7000 dans un proche avenir. Les principaux groupes d'organismes sont les Ascomycètes, les Basidiomycètes, les Coléoptères, les Diptères et les Hyménoptères. Le présent article décrit la structure de la base de données, l'information qui y est entrée pour chaque espèce et les différentes qualités de bois mort auxquelles les espèces sont associées. De plus il montre comment la base de données peut être utilisée et visualisée pour différents usages; quelques exemples de sorties de données sont fournis. Enfin l'article décrit les utilisations potentielles, la maintenance et les plans de développement de la base de données dont son accessibilité sur Internet.

Mots-clés: Base de données, pays nordiques, espèces saproxyliques.

SUMMARY. — The Nordic countries Norway, Sweden, Finland and Denmark are developing a shared English-written database with species-specific information about the ecology of saproxylic species. The database now contains information for about 6000 species and the number is expected to approach 7000 species in the near future. The main organism groups are Ascomycetes, Basidiomycetes, Coleoptera, Diptera and Hymenoptera. This paper describes database structure, information that is entered for each species and different qualities of dead wood that the species are associated to. Furthermore, the paper describes how the database can be searched and viewed for different uses, and it gives some examples of data output. Finally, the paper describes potential uses, maintenance, and development plans including making the database accessible on Internet.

Keywords: Database, Nordic countries, sproxylic species.

Dead wood is a key feature in natural forest ecosystems. Studies from unmanaged boreal forests indicate that dead wood makes up 20-30% of the total timber biomass (Syrjanen *et al.,* 1994; Sippola *et al.*, 1998), and up to 70% in recently disturbed areas (Krankina & Harmon, 1995). The amount of dead wood in North-European natural boreal forest varies between 60 and 80 m^3/ha, depending on latitude and altitude (Siitonen, 2001; Hahn & Christensen, 2004). In Central European temperate forest and mountain mixed forests, the amount of dead wood in natural forest conditions varies between 130 and 210 m^3/ha (Hahn & Christensen, 2004). These amounts of dead wood represent forest conditions that have prevailed on our planet for many millions of years. During this period a large number of species have evolved to utilize this historically abundant resource base. These organisms are either directly involved in the degradation of dead wood, or they interact with the decomposers through fungivory, predation or parasitism.

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In the Nordic countries there is a strong tradition to study the biological diversity in dead wood, rooted in classic works on beetles (Saalas, 1917; Palm, 1951, 1959) and fungi (Eriksson, 1958; Eriksson & Strid, 1969). Recently, such publications and unpublished data have been compiled in a database on the ecology of species living in dead wood (Dahlberg & Stokland, 2004). After the initial compilation a network of about 40 experts, mainly on different insect and fungus groups, have continued to update the database. Here, we present this work with emphasis on database structure and information content. Furthermore, we give some examples of output and suggest various uses of the database.

MATERIAL AND METHODS

BIOLOGICAL AND GEOGRAPHICAL SCOPE

The aim of the saproxylic database is to compile species-specific ecological information for all multi-cellular species that depend on decaying wood and to make this information available for different uses. The principal organism groups are Ascomycetes, Basidiomycetes, Coleoptera, Diptera and Hymenoptera. Furthermore, the database includes other insect groups (e.g. Hemiptera and Lepidoptera), additional invertebrate groups (e.g. mites and pseudoscorpions), vertebrates, mosses and lichens. Nearly all wood-inhabiting species live in terrestrial ecosystems (forests or parks), but some utilize wood submerged in freshwater or marine environments. Such aquatic species are also included in the database.

The database and experts judgements indicate that the total species richness of wood-inhabiting species in the Nordic countries is close to 7000 (Tab. I). By the end of 2007, the number of species in the database was about 6000.

TABLE I

Number of wood-associated species in different organism groups in Scandinavia[1]. The numbers are based on counting individual species or expert assessments

Fungi	
Ascomycetes	750
Basidiomycetes	1270
Lichens	220
Insects	
Coleoptera (beetles)	1400
Diptera[2]	1000 - 1200
Hymenoptera[2]	800 - 1000
Other insects[2]	> 200
Other species groups	
Acarina (Mites)[2]	300 - 500
Nematodes[2]	> 100
Myxomycetes[2]	150
Mosses	90
Vertebrates	54
Total	6400 - 7000

(1) The numbers are based on data from Finland, Norway and Sweden.
(2) The species numbers in these groups are expert assessments.

Denmark, Finland, Norway and Sweden represent the "target countries" for which the database provides species information. However, the database also includes information from surrounding countries (Fig. 1), especially for species that are rare or poorly studied within the Nordic countries. With time the database may be extended to cover a wider range of target countries.

DATABASE STRUCTURE

The database is organized as a relational database structure with the following main tables: a) reference library, b) species occurrences, c) locality objects, d) wood attributes, e) species interactions, f) generic species information (Fig. 2). In a recent upgrading, the database was moved to a new software platform using Microsoft Visual Studio 2005 and C# as implementation tools and MySQL as database engine.

Figure 1. — The geographical areas showing the four target countries and the most important countries representing the empirical basis for the saproxylic database.

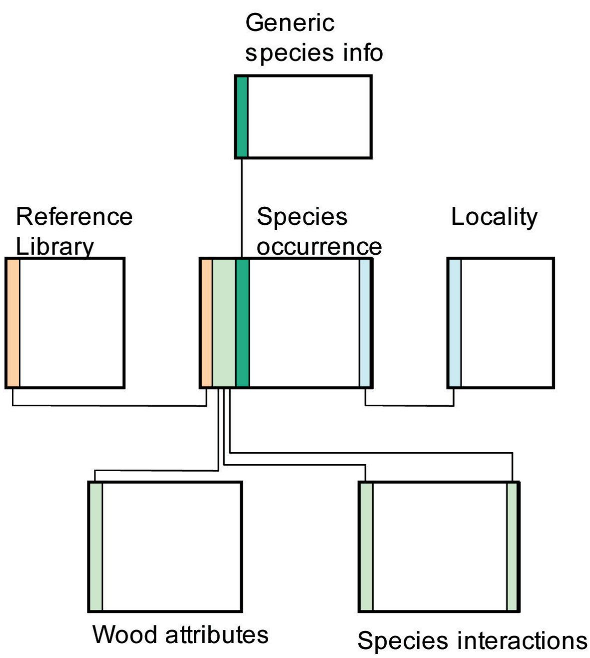

Figure 2. — The main tables of the saproxylic database with lines showing how the tables are connected through linking fields.

The reference library is a table with a record for each information source used by the database. Publications in scientific journals, biological society journals and various reports represent the most important information sources. The database also includes information from unpublished data sets (from research projects, master studies and PhD studies). Such data sets often become available after the data have been analysed and the intended publications have been made. Finally, the database contains information from museum collections, individual field observations, and expert judgments based on many years of field experience.

The species occurrence table essentially contains information about a species that is recorded in a place, with further links to ecology information in the wood attribute and species interaction tables, and more detailed geographical information in the locality table.

The wood attribute and species interaction tables contain all the ecological information in the database. The wood attribute table contains information that documents species associations to different wood attributes. The species interaction table documents relationships between species at higher trophic levels depending on dead wood through their saproxylic hosts, prey species or symbiotic species (Fig. 3). It is a rule to specify the geographical origin for each primary record. The geographical areas follow the definitions of Brummitt (2001), and form a global, hierarchical system where the basic unit typically corresponds to a country (Fig. 1).

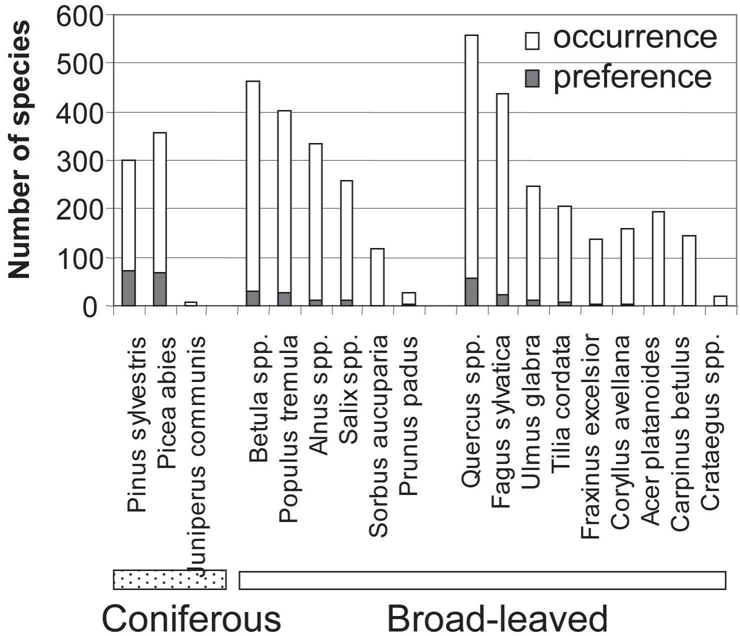

Figure 3. — Number of beetle species in Norway and Sweden that prefer or occur on individual tree species or genera.

The generic species table contains one and only one record for each species in the database. These records contain taxonomic position (Kingdom, Order, Family, etc.) the standard nomenclature (valid Latin name), national status (known or not known from each target country), and degree of wood dependency (obligate or facultative saproxylic).

PRIMARY SPECIES RECORDS

The species occurrence, wood attribute and species interaction tables contain the primary species records. Each species occurrence record has a RefID link to the information source stored in the reference library. The species name contains the standard name, whereas used name specifies the name used by the information source (if different from the standard name, e.g. old information using outdated nomenclature). The comments field is a free text paraphrasing the information from the information source and is translated into English when the source uses another language. Development stage specifies which part of the life cycle is documented (larva, pupa, adult; for fungi: mycelium, fruit-body).

Each species occurrence record is linked to a wood attribute record where the information is coded as qualitative or quantitative observations according to a large number of specific wood attributes (see below).

A species occurrence record can also be linked to another species occurrence record to form a species interaction record. This record defines the functional role of the species with respect to the other (e.g. wood decomposer, detrivore, fungivore, predator, parasite, scavenger, epixylic).

The data is entered into Excel files according to specific guidelines outlined in Stokland (2007). These files are subsequently uploaded to the database through an import procedure that performs numerous automated checks of correct name spelling, valid codes and referential integrity between different tables.

Qualitative and quantitative records

The association of a species to different wood attributes or another species is documented by using qualitative or quantitative records (see Tab. IIIb). The following codes are used for qualitative data:

— preference for a particular wood attribute (as indicated by the information source).

— occurrence on at least one wood unit with the particular wood attribute condition. This is the most commonly used code, as no assumption is made concerning preference for the wood attribute in question.

— irregular occurrence. This code is used for an observation on a particular wood attribute where one would normally not expect to find the species.

Quantitative records are used when the information source states the number of dead wood units or live trees on which the species was observed. In these cases the actual number is entered in the record instead of the qualitative codes.

Wood attributes

The wood attribute table contains information about individual species and their usage of a large number of wood attributes. All the attributes have been defined as specific categories and most of them are listed below. A complete list of attributes and their definitions is presented in Stokland (2007). The wood attributes are grouped into 7 major classes:

(1) Host tree. Host tree is a hierarchical category where one normally enters a species name (genus and epithet). But one can also enter higher categories such as genus (*Betula* spp., *Quercus* spp., etc.), "coniferous" or "broad-leaved tree". One can also enter lower categories like subspecies and hybrids between trees.

(2) Decay stages and rot types. The decay stage refers to the local state of decay that the species actually utilizes, and not some average decay of the whole tree (see wood types, below). The database uses two categories for live wood and five for dead wood: Live wood, Dying wood, Recently dead, Weakly decayed, Medium decayed, Very decayed, Almost decomposed. In addition there are two categories for rot type: Brown rot, White rot.

(3) Dimension. The database uses 7 diameter intervals to specify occurrence on different dimensions: 0-1 cm, 1-5 cm, 5-10 cm, 10-20 cm, 20-40 cm, 40-80 cm, > 80 cm. For species utilizing the trunk, the DBH is the reference diameter. For species utilizing the branches or tree top, the local branch (tree top) is the reference diameter.

(4) Mortality factor. The mortality factor primarily focuses on how the tree died rather than the specific mortality agent (which can be several ones operating in combination). The following categories are used: Died standing, Uprooted, Broken mechanically, Broken by rot, Fire, Cut by man.

(5) Microhabitats. Nearly all saproxylic species utilize some distinct microhabitat(s) formed by the tree or other saproxylic species. A microhabitat is a smaller section of a live or dead tree. The most important ones are: Bark interior, Under bark, Wood surface, Wood interior, Insect galleries, Sap run, Rot hole, Tree cavity, Fire-charred wood.

(6) Wood type. The wood type refers to the whole tree or unit of dead wood where a species is found. Several microhabitats can be present in a particular wood type, i.e. a live tree can contain a dead heartwood section or a tree cavity with wood in different stages of decay. The following categories of wood types are used: Live tree, Over-mature tree, Standing dead tree, Lying trunk or branch, Stump, Bolt, Logging residual, Building, Other modified wood.

(7) Surrounding environment. This class of wood attributes refers to the environment surrounding the wood unit where a species occurs. The following categories are used: Sun-exposed, Semi-shady, Shady, Buried in soil, Freshwater, Marine water.

Species interactions

Perhaps more than a thousand saproxylic species in the Nordic countries depend upon woody material by feeding on other species that get their nutrition from woody material. Such species interactions can often be very specific and the database is designed to capture these relationships using the species interaction table. Essentially the table has three elements: species A (on the "host" side), species B (the "associated" species), and the interaction form (fungus-fungivore, prey-predator, host-parasite, etc.). Furthermore, one can specify attributes such as the part of the life cycle being involved in the interaction both on the host and the associated side. Just like the wood attribute records, the species interaction records can be qualitative or quantitative.

AGGREGATION, SELECTION AND OUTPUT OF DATA

Aggregation levels

The database contains primary species records with a high degree of ecological and geographical resolution. The information about each species is typically scattered across several records originating from different information sources. This resolution is often too detailed for various uses and the database is organized to present the information using four aggregation levels with decreasing amount of detail (Tab. II, Fig. 4). One can choose the aggregation level by specifying alternative views of the primary species records. Each view performs specific pivot transformations of the data and presents the selected primary records according to the aggregation level. In the results we present some examples to illustrate these aggregation levels.

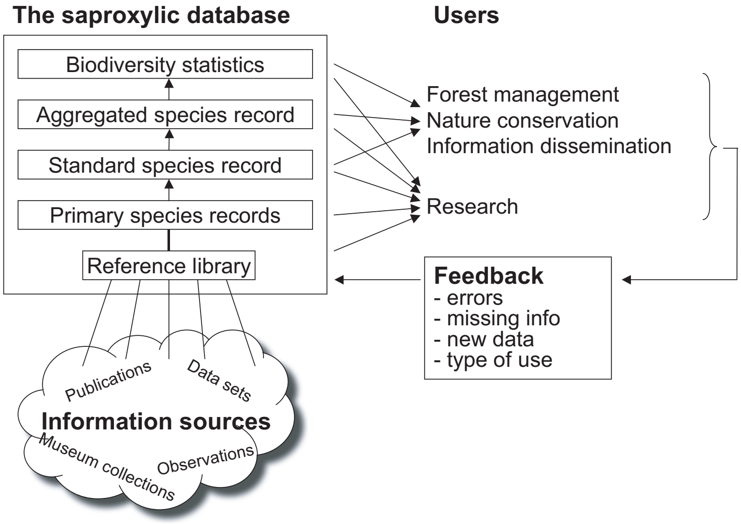

Figure 4. — The Saproxylic database compiles data from a wide range of information sources. The data are aggregated and presented with different degree of detail for various uses. All users should provide feedback on shortcomings and usefulness of the database.

TABLE II

The aggregation levels of species information from the saproxylic database

Aggregation level	Characteristics	Type of species information
Biodiversity statistics	Summary statistics of species numbers in different functional and ecological groups.	No individual species information.
Aggregated species record	Each aggregated species record is simplified by joining similar wood attributes into wider categories.	Species classified as specialist-generalist with respect to wider wood attribute categories.
Standard species record	All primary observation records for a species are combined into one summary record. Full resolution of wood attribute categories.	Coded relationships (preference, occurrence, irregular occurrence) for each wood attribute category.
Primary species record	Each record reflects what an individual information source says about a particular development stage of a species.	Free text paraphrasing the information source. Quantitative or qualitative data for each wood attribute category.

Search criteria

The aggregation level is one way to tune the output from the database. Another way is to select which parts to view.

The search criteria can be taxonomical, i.e. one can specify which organism group, family, genus or species one wants information about.

One can also specify the geographical scope, both in terms of target countries and empirical basis. When specifying the target country (or countries) one receives information about the species that are known from the country according to the national status in the generic species table. When specifying the empirical basis area one selects information from the primary species records that originate within this area. Thus, one can summarize the ecology of some species in a country based on knowledge from that country or a wider geographical area.

Furthermore, one can select species that are obligate saproxylics, facultative saproxylics, or both.

Output formats

The output from the database is presented on the screen for browsing and further refinement of the selection criteria. When the result is satisfying one can download the output as an Excel file.

RESULTS

PRIMARY RECORDS AND STANDARD SPECIES INFORMATION

The primary species records represent the information basis of the database. Table III displays a small subset of primary beetle records from the database. Table IIIa shows information that has been entered from the information source, and table IIIb shows how this information is coded into the wood attribute categories.

In table IV, species information from table III is combined and transformed to standard species records. The main changes from the primary species records are the following: all comments, i.e. the text paraphrased from the information sources, are omitted; quantitative records are transformed to qualitative records; different preference levels (i.e. preference, occurrence, irregular occurrence) are combined, usually by giving "preference" and "irregular occurrence" priority over "occurrence".

TABLE IIIA

A selection of fields from 6 primary species records in the species occurrence table

Ref ID	Used name	Standard name	DS	Comments	Geogr. area	Localiy ID
53		*Cetonia aurata*	L	The larvae develop under bark and in strongly decayed wood. It occurs in wood of broad-leaved trees. Searches of the species in hollow trees indicate that this is not a common development place. It has been found in old, sun-exposed manure heaps.	Sweden	
53		*Hylis cariniceps*	L	The larvae develop in a particular kind of brown-rotted wood, typically in big standing or lying trunks that have been dead for 5-10 years. Often this kind of rot is found in narrow sections adjacent to cracks in the trunk. Occurs more often in *Picea abies* than *Pinus sylvestris*, also found in several broad-leaved tree species.	Sweden	
303		*Hypocoelus cariniceps*	L	Larvae have been found in a *Carpinus betulus* branch on the ground. The larvae made galleries in the wood where a reddish, somewhat moist rot had developed. The next year Leiler reared the species from a dead *Hedera helix* stem.	Sweden	
53		*Buprestis octoguttata*	L	The species is almost exclusively confined to *Pinus sylvestris*, but in dry and very hot sites it probably also uses *Picea abies*. Larvae develop primarily in dead sun-exposed roots above ground, typically 5-10 cm thick. Often found in roots damaged by trampling and machinery; the natural habitat is probably trees/roots damaged by forest fire. Larvae have also been found in woody material on the ground in sunny positions.	Sweden	
53		*Saperda populnea*	L	The species primarily utilizes *Populus tremula* and different introduced *Populus* species. In northern Sweden the species also uses different *Salix* species. Larvae develop in 0.5 to 1 cm thin branches or stems of live trees (often ca 1 m high). The larvae first live in the cambium zone and later enter the centre of the stem that develops a swollen gall formation around the attack site.	Sweden	
123		*Saperda populnea*	L	Larvae found in galls from 947 shoots of live *Populus tremula* (607), *Salix caprea* (188) and *Salix phylicifolia* (152) in a study of parasitism and predation from enemies.	Finland	
53		*Scolytus ratzeburgi*	L	The species develops in dying or recently dead *Betula pendula* or *Betula pubescens*. The larvae develop in the cambium zone of big trunks, thinner parts of the trunk in the crown and big branches.	Sweden	
RefID codes: 53 = Ehnström & Axelsson, 2002; 123 = Pulkkinen & Yang, 1984; 303 = Palm, 1959.						

TABLE IIIB

The information from table IIIa coded into host tree and decay stages in the wood attribute table (p = preference, x = occurrence, i = irregular occurrence)

		Host tree										Decay stage						
Ref ID	Species	*Pinus sylvestris*	*Picea abies*	*Betula* spp.	*Populus tremula*	*Salix caprea*	*Salix phylicifolia*	*Salix* spp.	*Carpinus betulus*	*Hedra helix*	Broad-leaved trees	Live, healthy	Live, dying	Recently dead	Weakly decayed	Medium decayed	Very decayed	Almost decomposed
53	*Cetonia aurata*										x					x	x	x
53	*Hylis cariniceps*	x	p								x					p		
303	*Hypocoelus cariniceps*								1	1						1		
53	*Buprestis octoguttata*	p	i												x			
53	*Saperda populnea*				p			x				p						
123	*Saperda populnea*				607	188	152					947						
53	*Scolytus ratzeburgi*			p									x	x				

TABLE IV

The information from table IIIb converted to standard species records (p = preference, x = occurrence, i = irregular occurrence)

		Host tree										Decay stage						
Ref ID	Species	*Pinus sylvestris*	*Picea abies*	*Betula* spp.	*Populus tremula*	*Salix caprea*	*Salix phylicifolia*	*Salix* spp.	*Carpinus betulus*	*Hedera helix*	Broad-leaved trees	Live, healthy	Live, dying	Recently dead	Weakly decayed	Medium decayed	Very decayed	Almost decomposed
53	*Cetonia aurata*										x					x	x	x
53, 303	*Hylis cariniceps*	x	p						x	x	x					p		
53	*Buprestis octoguttata*	p	i												x			
53, 123	*Saperda populnea*				p	x	x	x				p						
53	*Scolytus ratzeburgi*			p									x	x				

AGGREGATED SPECIES INFORMATION

Many wood attributes have a hierarchical structure where some categories are ecologically similar to each other while others are very different. A species that only uses a narrow range of wood attributes within an attribute class is categorized as a specialist with respect to that class. All species are categorized as some kind of specialist, generalist or insufficiently known with respect to each of the seven wood attribute classes described in the methods section.

Table V presents the species from table IV, but here they are classified as specialists or generalists relative to the wood attribute classes.

BIODIVERSITY STATISTICS

The most general way to view the database content is to get summary statistics of species numbers that belong to some taxonomic group within a geographical area or are associated to

TABLE V

The records from table IV converted to aggregated species records

Species	Host tree	Decay stage	Diameter class
Cetonia aurata	Broad-leaved specialist	Late decay specialist	Unknown
Hylis cariniceps	Conifer preference	Mid decay specialist	Medium-large preference
Buprestis octoguttata	Conifer specialist	Early decay specialist	Sma
Saperda populnea	Broad-leaved specialist	Live specialist	Very small specialist
Scolytus ratzeburgi	Broad-leaved specialist	Early decay specialist	Generalist

woody material in specific ways. Figure 3 illustrates this kind of biodiversity statistics. The figure shows the number of beetle species in Norway and Sweden (combined) that prefer or occur on individual tree species or genera. These numbers were derived from standard species records of 1257 beetle species in 2003. The result shows that among the species being observed on a tree species about 10% of them actually preferred this host tree. Another query based on the aggregated records of the same 1257 species revealed that 289 species (23%) preferred coniferous trees, 654 species (52%) preferred broadleaved trees, 138 species (11%) were generalists using both coniferous and broad-leaved trees, whereas 176 species (14%) were insufficiently known. In other words, a rather small proportion of the species preferred an individual tree species, but 75-90% of the species preferred either coniferous or broad-leaved trees. The uncertainty interval is caused by the insufficiently known species.

The general picture presented above is quite reliable, although the exact numbers are outdated today. The reason is that the database is being updated with information about more species and some of the species that were in the database in 2003 have now been excluded.

DISCUSSION

In this paper we have presented the main features of the saproxylic database. We will now discuss some potential uses, routines of database updating, and further development (Fig. 4).

USES AND USER GROUPS

Scientific research

The database has already been used as the basis for several scientific reports and papers (Dahlberg & Stokland, 2004; Stokland *et al.,* 2004; Jonsson *et al.,* 2005) and we foresee that researchers will be regular users of the database. One use is to extract information about species associations to different wood qualities and analyse responses of individual species and species richness in a predictive modelling context. Another use is to analyse species diversity patterns across different wood attributes and make review papers on the ecology of separate organism groups. A third, more indirect use, is to extract species classifications (obligate-facultative saproxylic, decay preference, host tree preferences, etc.) and use this information to sort species lists from field studies. At least 5 scientific publications have already used the database for this purpose.

Even if the database appears rich in content, it does have shortcomings. We therefore recommend researchers who wish to use the database to contact the relevant working-group (see database maintenance, below) and check whether the database actually provides reliable data for the intended use. We have already discouraged specific uses because the results would be quite misleading based on the current database content.

Forest management

The database is relevant to adjust management practices directed towards the biodiversity in dead wood. By using the number of species associated to different dead wood attributes one can evaluate the cost-effectiveness of leaving different types of dead wood in the forest for biodiversity protection. Another use is to develop species-specific conservation measures for management plans inside and surrounding localities of red-listed species. The database can also be used to define species guilds associated to different combinations of dead wood qualities (large-dimension and medium-decayed spruce logs, standing dead pine trees with loose bark, tree cavities in ageing oaks, etc.). Furthermore one can select some umbrella species representing each guild to give the biodiversity a “face”, and quantify the number of species underneath each umbrella.

Nature conservation

The database can be a part of the knowledge base when supplementing existing networks of forest reserves. By quantifying the number of species being associated to different tree species one can assess to which extent different forest types are over-represented or under-represented with respect to cover the full range of species diversity in dead wood. When the species composition within established reserves is known one can use the database to assess favorable conservation status for the saproxylic species based on their substrate requirements and the actual availability of these substrate qualities.

Feedback on information content

As the database becomes accessible for various uses, different users will spot errors, know missing information that ought to be in the database, and hopefully provide new data. We consider feedback from users to be instrumental for a successful development of the database (Fig. 4).

Database updating and maintenance

The database is developed and maintained by separate working groups established within the Nordic saproxylic network. These working groups carry out data entry and quality control for separate taxonomic groups.

Most of the activity in the working groups has focused on data entry. Since the expert network was established in 2004, we have screened and digitized information from more than thousand papers, books, data sets, etc. This work will continue on a large scale at least until 2008, and hopefully we will manage to enter most of the available information from the Nordic countries. We have experienced that a high level of expertise is needed among the persons participating in the data entry process. One needs to correctly interpret what is stated by the information source, one needs expertise on the ecology of saproxylic species, and finally one must understand the wood attribute definitions in the database in order to translate the original information into these categories.

We have also started to enhance the quality of the database content. One part of this work is to sort out exactly which species qualifies as saproxylic. In this work we classify the species as “obligate saproxylic” - completely dependent upon dead wood for fulfilling at least one part of the life cycle; “facultative saproxylic” - a large proportion (minimum 30-40% of known occurrences) utilize dead wood in a particular life cycle stage, but alternative resources is also used; “saproxylic” – either obligate or facultative, but existing data is too sparse to decide. The challenge is to sort out all the borderline cases among facultative species that partly use woody material (or other saproxylic species) and partly use other media or species as alternative resources.

Another aspect of quality enhancement is to highlight or correct misleading/erroneous information from the information sources. A typical example is to update old nomenclature by entering the currently valid name in addition to the name used by the information source.

On-going development

Until 2006, the database has been developed as a collection of separate files: an EndNote file for the reference library and a set of Excel files for the other tables illustrated in figure 2. This platform is unsatisfactory for several reasons and the database went through a major revision in 2006 and 2007.

One change was to revise the internal database structure. The most important revision was to merge host tree associations and species interactions in a common structure. In the new version the wood from host trees is viewed as a species (which it in fact is) just like any other species. Then all records will be species-species interactions where one can specify any kind of ecological interaction (e.g. host tree – decomposer, fungus – fungivore, prey – predator, etc.) and various attributes specifying details about the species on either side of the relationship. We will also structure the wood attributes in a hierarchy that makes it straightforward to join detailed attribute categories into broader categories.

Another change is to use a software platform that facilitates database access through Internet. From 2007 the database has become available on Internet at the address www.saproxylic.org. The Internet version is still under construction as we continue to develop new features to facilitate different uses of the database.

In the near future we intend to introduce additional features both for data providers and database users. One feature is to add new fields to link species occurrences to specimens residing in collections (private or public). Another feature is allowing data providers to attach special licences to previously unpublished data specifying that users need to contact the data provider if he or she wants to use the data for specific purposes (e.g. publish a report or scientific article). Still another feature is to allow users to express doubt concerning the validity of specific pieces of information in the database. In this way, the database can serve as interactive platform for cleaning up misleading or wrong information about saproxylic species.

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